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ABSTRACT

Ideas and techniques for planning and managing space and facilities in complex colleges are discussed with historical information on the growth of higher education in the United Kingdom provided as background. The University of London established a research team to determine patterns of space use and to devise methods of allocating teaching activities to teaching spaces. The team focused on students' use of university buildings for teaching activities and nonteaching activities (e.g., libraries, cafeterias). A diagram, which is included, was completed to show how utilization can be measured for an individual space. Shown are space available and activities taking place within it, room capacity and the number of people involved, and room availability and actual or potential meeting hours. An interactive computer program was developed to analyze room utilization, and specifically: to improve space use and solve timetable problems; to provide statistics on space utilization and movement patterns in order to isolate under- or over-provision of space; to assess the impact of new policy decisions on patterns of space use; to enable administrators and faculty to understand the effects of personal or departmental preferences on space use and provision; and to assist campus planning. Flow charts for the space utilization system are presented, along with information that may be included in the files. A bibliography is appended. (SW)

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MAKING EFFECTIVE USE OF SPACE IN COLLEGES

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Grace Kenny

Grace Kenny took her first degree in Politics, Philosophy and Economics at Oxford University. She then worked at University College London in the Departments of Political Economy on, among other things, a study of building cost indices and of Environmental Studies where much of the work on the use of educational buildings had its beginnings. In 1975 she moved to the Architects and Building group of the Department of Education and Science, where she is now Senior Research Officer She completed a Ph.D. on the shared use of polytechnic accommodation in 1978 as an external student of the University of London. She obtained a Licence de Lettres Modernes as an external student of the University of Lille III in 1982. She has carried out space use studies and has lectured and written on educational building management for some years and is currently becoming more involved in the international aspects of educational resource management.

Derek Wickham

Derek Wickham graduated in Aeronautical Engineering and after a spell in industry as an electronics engineer moved to lecturing in Further Education Colleges. After taking an MSc in Computing Science at City University he developed a software package to aid with the management of time-tables at Tottenham College of Technology. In 1981 he was appointed as Research Fellow at the Further Education Staff College to work on the FEMIS project - an integrated management information system for use in Further and Higher Education Colleges in the U.K. This software is currently in use by 86 colleges. He is now continuing the development of new modules for FEMIS and working for a Ph.D. at Loughborough University on Computer Assisted Time-tabling.

1. Introduction

This paper describes some ideas and techniques which have been developed over the years in the context of planning and managing space and facilities in complex educational institutions. The built plant of such institutions represents an important capital outlay and the money required to keep it functioning adequately (expenditure on day to day maintenance, long term maintenance, repairs and minor works) can constitute up to 25% of the annual recurrent budget. It is thus important to ensure that the best use possible is made of this plant, that it can respond effectively to the demands made of it and that it can be altered in disposition or amount as demands change.

The first part of the paper describes briefly the background and circumstances which gave rise to the notion of studying space use. A few basic definitions are then given, followed by some techniques for collecting useful information and for analysing it. Finally a computer system is described which is designed to make optimum use of an institution's teaching accommodation. A list of references and a comprehensive bibliography are appended.

2. Historical perspective

During the middle and late 1960s in the United Kingdom, there was considerable expansion in the field of higher education. The prevailing attitude was summed up in the Robbins Report (1963) which recommended that everyone who was suitably qualified should have free access to higher education. This meant that there was a great deal of new building, both as additions to existing universities, and as completely new institutions. At the same time a new breed of institution was developed, the polytechnic (see DES, 1966), to form a tier of higher education institutions parallel to the university sector, but more technologically oriented and with very strong local links, the latter characteristic being a function of the fact that most polytechnics were born from mergers among local technical, commercial and art colleges. The pattern of post-compulsory education as established at that time has remained largely the same, with 42 universities, 30 polytechnics and some 600 colleges of further education, although recently some 60 of the last have transformed themselves into institutions of higher education by concentrating more and more on high level (degree level) work.

Although many brand new universities were established at that time, the older city centre foundations were also enjoined to accommodate greater numbers of students. The case of University College London, (the original college of what is now the federation which makes up the University of London and founded in 1824) was not untypical. Although willing to take on additional students in order to respond to pressures from government and public opinion, the College authorities felt that it would not be possible to find space for them within the existing buildings and that new building would be out of the question on a constrained,

historic, urban site.

It was therefore decided to set up a research team whose brief it would be to study the current use of the College's accommodation and to suggest ways in which it could be altered and improved. This group was the Unit for Architectural Studies, working for ten years or so in the Faculty of Environmental Studies (constituted by the Departments of Architecture and of Town Planning). The thrust of the group's work was therefore always two-fold. First, to ascertain what the current patterns of space use were, by carrying out empirical surveys and second, to devise methods of allocating teaching activities to teaching spaces in such a way as to optimise the use of buildings and facilities. The first half of the group's work was very much the responsibility of Grace Kenny, and the second was that of Dr. Carole Rawlinson whose computerised space allocation system is described in Section 6, and who now works as Deputy Director of the Medical Architecture Research Unit at the Polytechnic of North London.

3. Surveying techniques

In order to find out how people were using the University's buildings it was decided to concentrate on those parts of them which were used by students (arguably the prime clients of institutions of higher education), and to divide these into two types - those used for non-teaching activities and those used for teaching activities.

a. Non-teaching activities. The spaces used for these are all those which are generally of open access to students and which are not timetabled (except in the sense that they may have to adhere to set opening hours). They include libraries, refectories, common rooms, cafeterias, bars, reading rooms and so on. The method of finding out how they were used was simple in the extreme. The members of the research team visited each space to be surveyed and noted the number of people present at regular intervals over an agreed period (a day, a week or even an entire term). A useful distinction was made between those sitting and those standing, thus allowing a difference to be drawn between those eating and queueing in a refectory, and between those studying and browsing in a library. Additional surveys were carried out where numbers entering and leaving designated areas were clocked and accumulated over given periods: these flow counts were capable of showing different rates of traffic and of giving continuous occupancy levels but in terms of resources required, they are more expensive to carry out. As a result of such studies, in a wide range of institutions, from universities to schools, it has been possible to make useful alterations to space and facilities, and, perhaps more importantly, to the way in which they are managed. For example, branch libraries have been closed, refectory opening hours have been extended, seating areas have been rearranged, methods for collecting and paying for food have been improved, and so on.

b. Teaching activities. The other element in the fact gathering exercise was to study the way people use spaces for timetabled teaching activities: such spaces typically account for 70% of a higher education institution's floor area, so that their efficient use should be a prime target of an educational administrator's task. Several methods for collecting accurate information were suggested and tested. These included: using existing, annotated, staff timetables; using class registers; asking staff members to fill in a sheet left in each teaching space with the number of students present at each teaching period; carrying out on the spot occupancy counts (as for non-teaching spaces). In the event, all methods except the last proved very unwieldy and extremely unreliable.

It is recommended therefore, that to obtain accurate information on how people are using spaces, it is best to visit each space once each teaching period (which is normally one hour long), over an agreed period of time (normally one, "typical", teaching week), and to note the number of students present, between 09.00 and 17.00 each day. Thus the resulting data bank will consist of a matrix with, on one axis, a certain number of rooms (however many it is decided to survey) each with a unique identifier, location, primary use and capacity, and on the other 40 counts of occupancy. From this array of data it is possible to calculate, for each room, for sets of rooms (defined by e.g. type, location or capacity) and for all rooms, the three fundamental measures of levels of room use: these are frequency, average occupancy and utilisation, and are fully explained in the following paragraphs, Section 4. The methods of analysis, using specially written computer programs, are shown in section 5.

Figure 1 shows a typical day in the life of (a) a university and (b) a polytechnic based on information collected on space use.

Overall it was found, and although people are becoming more conscious of the need to use buildings efficiently, it is still found, that there is a great deal of spare capacity in a university's or college's accommodation, not only in terms of space, but also it terms of time; and the following methods of assessment were designed to take the time element, all too often forgotten, into account.

4. Definitions and principles

Figure 2 is an illustrative diagram showing how utilisation can be measured for an individual space. The outer, solid, graph represents one space, available for 40 hours a week, and with a capacity of 100 workplaces (giving a total potential capacity of 4000 person hours); the inner graph represents the activities taking place in the space (which may be actual ones as revealed by empirical surveys, or potential ones, as shown by a curriculum or plan) which, in this example, consist of 80 students meeting for 10 hours and 60 students meeting for 10 hours. (The meetings have been juxtaposed in descending order of size; no

chronological hierarchy is involved). Thus from this example it is possible to calculate:

$$\text{Frequency factor} = \frac{10+10}{40} = \frac{20}{40} = 50\%$$

$$\text{Average occupancy factor} = \frac{(10\times80)+(10\times60)}{20} \Big/ 100 = 70\%$$

$$\text{Utilisation} = 50\% \times 70\% = 35\%$$

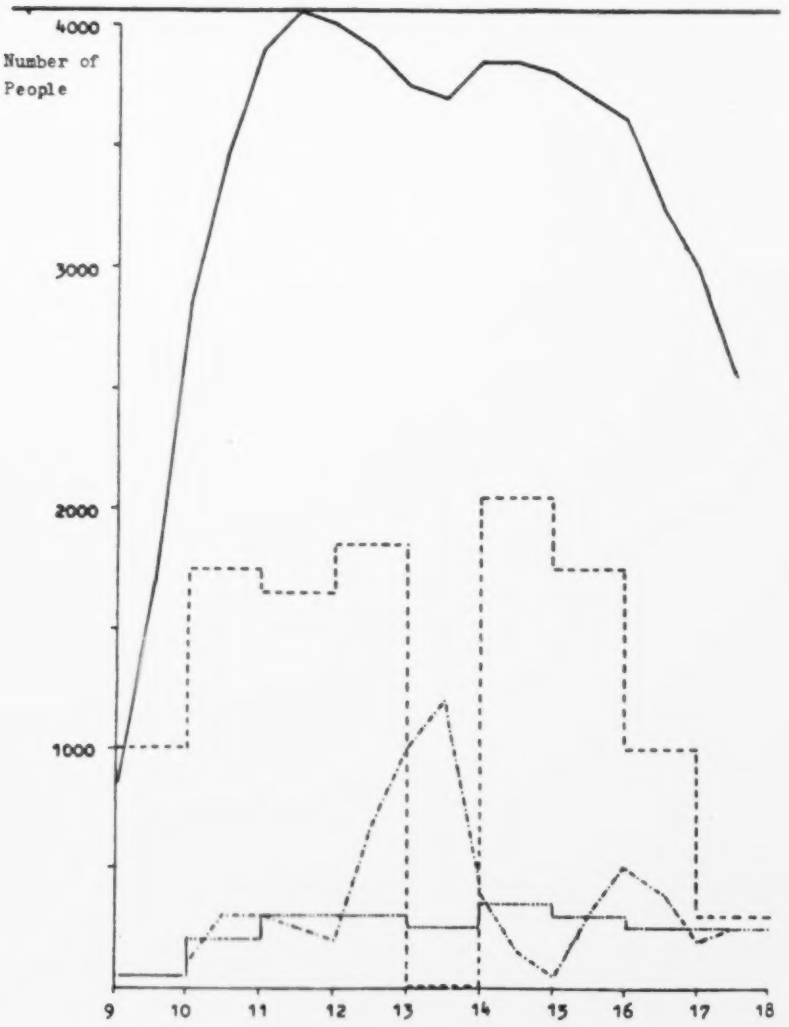
Such calculations may be carried out for individual rooms and groups of rooms and should also always show the constituent factors of frequency and average occupancy if they are to be useful to an educational manager. This illustrative figure of 35% is in fact not untypical in real life and although it might appear shockingly low at first sight there are good reasons why such levels are rarely bettered, particularly in older, traditional types of institution. The reasons have principally to do with

a. a lack of objective information

b. the difficulty of matching group sizes to room sizes (average occupancy is low)

c. problems of peaking over the teaching week (so that a high number of rooms is made available at the most popular time, rooms which remain empty for the rest of the week). The suite of computer programs described in Section 6 is designed to eliminate these problems, and others as well. These methods of carrying out surveys and of assessing their result are shown in more detail in Kenny (1983).

(a) Number of people on site, receiving instruction and using libraries and refectories at University College London



b) Number of people on site, receiving instruction and using libraries and refectories at Leicester Polytechnic.

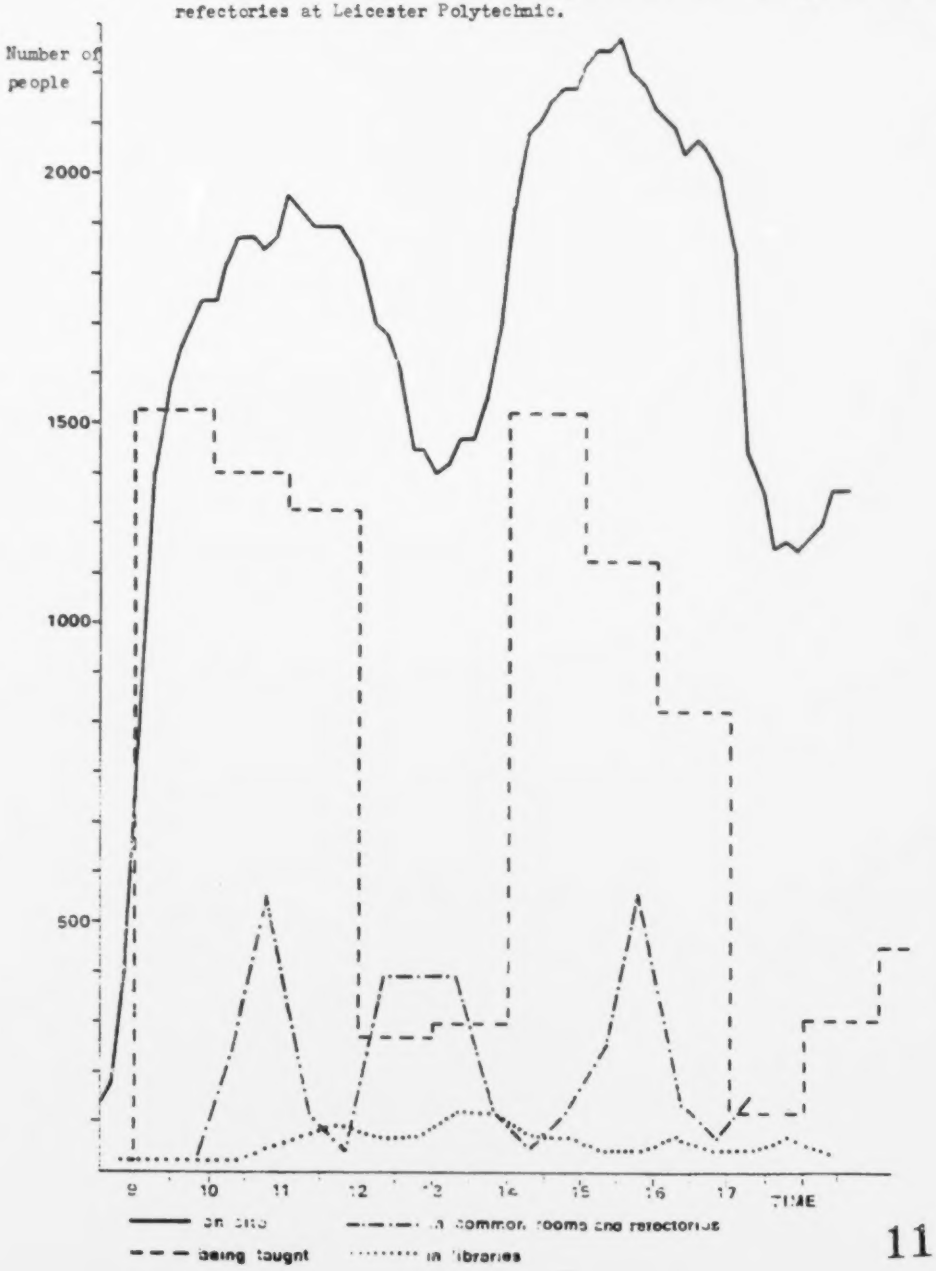
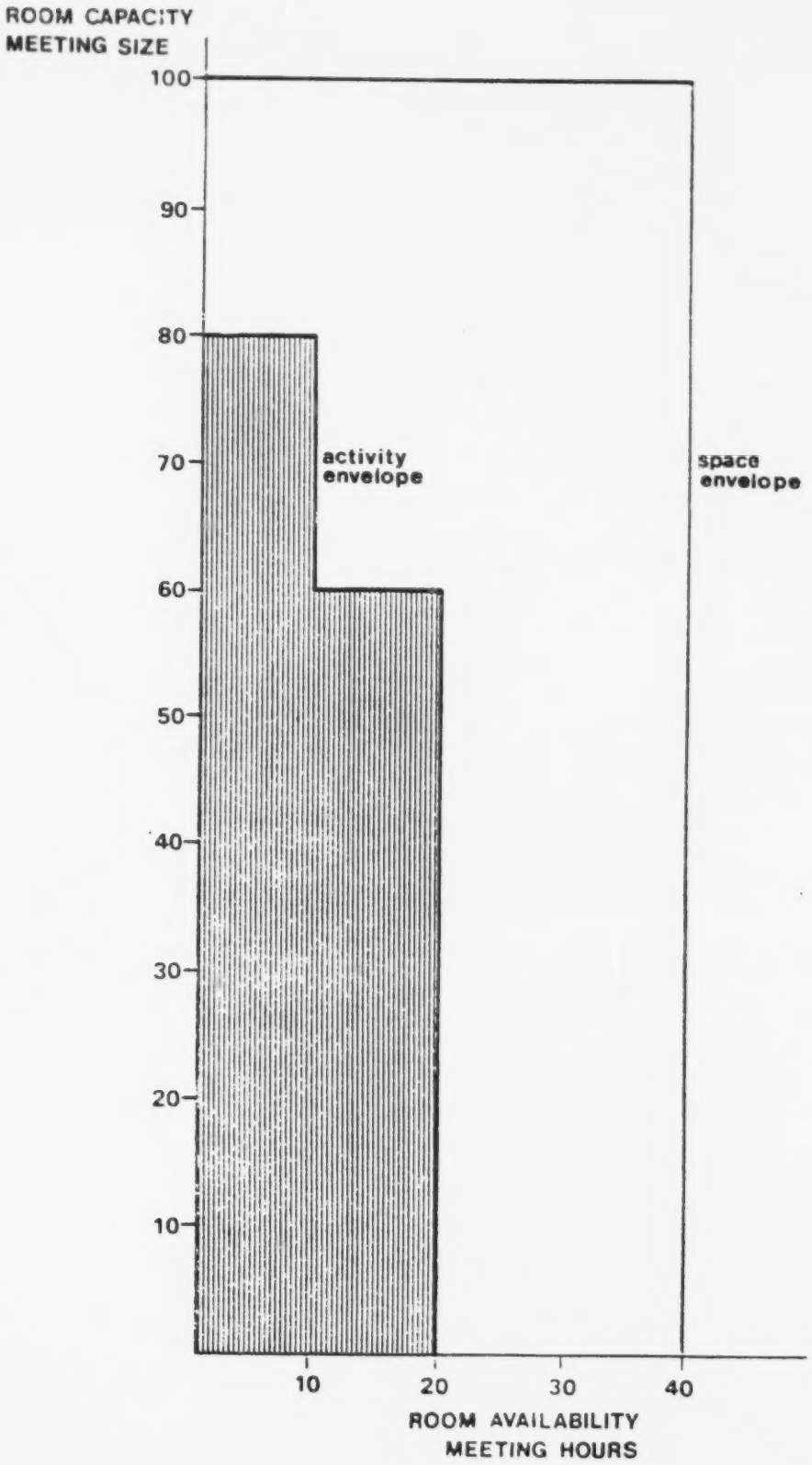


Figure 1 A day in the life of a) a university b) a polytechnic

Figure 2 UTILISATION



5. Data Analyses

The calculation of the frequency, occupancy and utilisation of individual rooms is easy to do by hand. Rather more time-consuming is the display of this data in graphical form as histograms and space use envelopes. However to be useful for institution research the data needs to be analysed for groups of rooms (by type and location) and space use graphs produced for these groups. This is extremely tedious and time-consuming by hand.

An interactive computer program has been developed which accepts the results of the room surveys and produces under direction of the user, analyses and graphical output for individual rooms and groups of rooms.

Derek Wickham has been involved from an early stage in the computer programming required to analyse room use data. The latest embodiment of the software is part of the FEMIS package (Birch, 1982,) which at present runs on a range of CP/M based micro computers.

The Room Utilisation Module is an integral part of the FEMIS suite but can also be used on a stand-alone basis. This is achieved by arranging for the programs in the Room Utilisation Module to operate on a **Room Loading File** which can be produced either from the analysis of the time-tables contained in the FEMIS core module or by entering by hand the results of a room use survey.

The data requirements for the Room Utilisation Module are shown in Figure 3, over.

ROOM UTILISATION ANALYSIS - SYSTEM OUTLINE

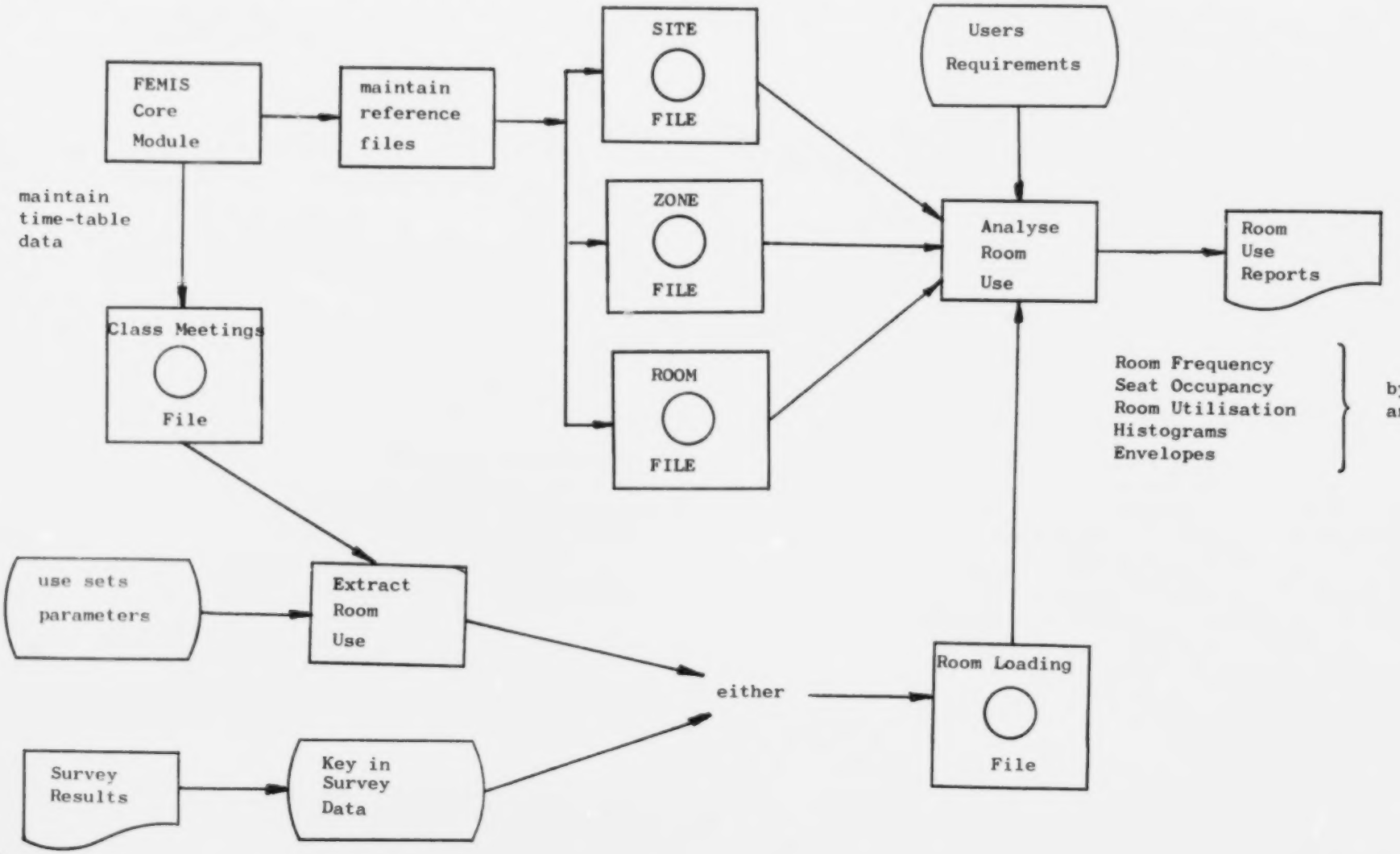


Figure 3

Before any room use data can be analysed, the rooms in the survey need to be classified. This data is held in a separate file and the analysis program consults this file to obtain room details information. Information in a room file may include

- Type (e.g. classroom, laboratory)
- Zone (location in the Institution)
- Capacity (number of student workplaces)
- Area (which may relate to capacity)

The information for the room file may be collected by visual inspection together with plans of the building and time-tables.

The room loading file contains the number of students in each room for each time-slot for each day of a week. This data can be entered direct from the room use survey forms, facilities being provided to move easily from time-slot to time-slot and room to room. The creation of this file from the time-table data is a simple matter of selecting the appropriate menu choice from FEMIS and choosing the week number and size of time slot. The appropriate data is then extracted, by FEMIS, from the time-table data base.

An example of an analysis produced from a room use survey is given in Figures 4 and 5. This output is for the institution as a whole, similar analyses being possible for parts of the institution. Note the : symbol used to show an available space and O symbol for an occupied space (or group of spaces). The space use envelope in Figure 4 superimposes the classes in order of size on the rooms in order of size. This gives a quick visual check of the way the space is used. For example the comparison of the area : + ⊙ with the area O + ⊙ is the room utilisation. In general the vertical axis gives seat occupancy and horizontal axis the room frequency.

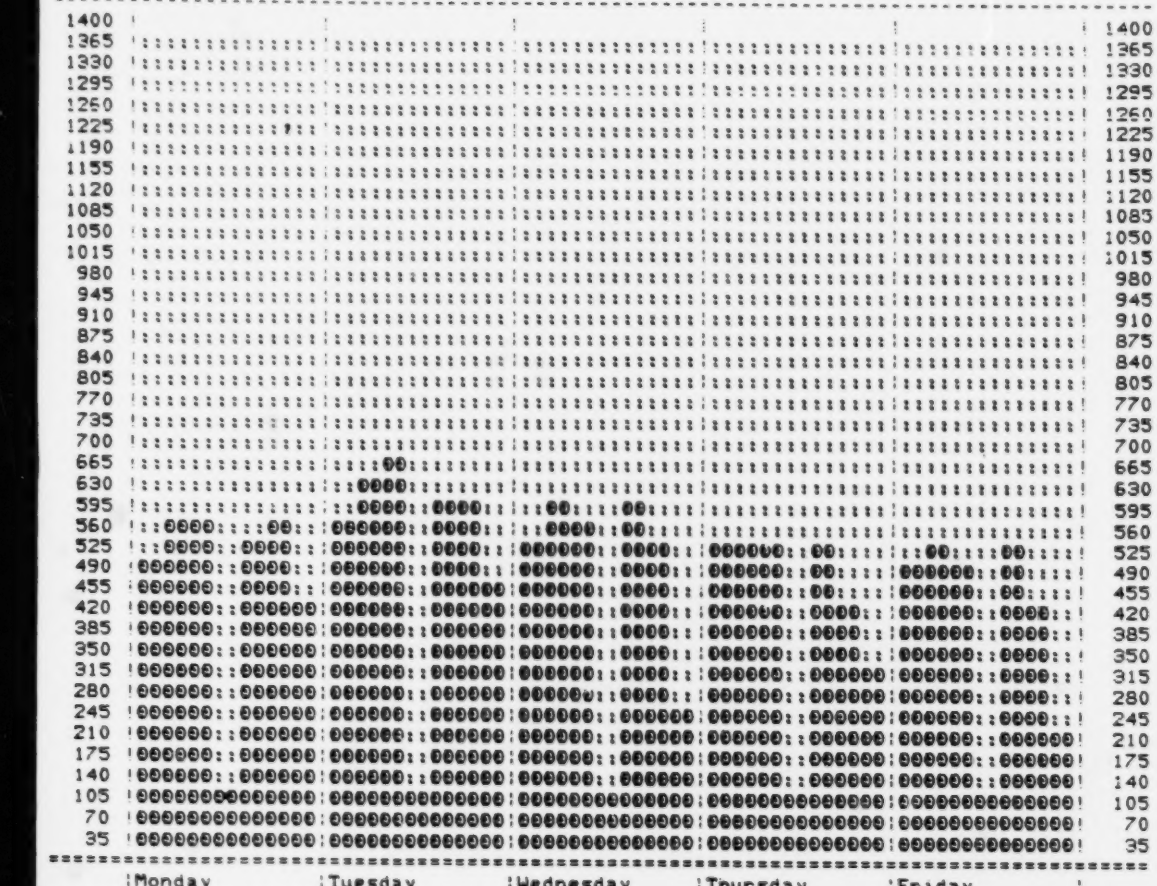
FIGURE 4

COLLEGE OF FURTHER EDUCATION

Room : ALL ROOMS
Room Type : ALL TYPES
Site : ALL SITES
Capacity : 1393

FEMIS Release 2a

Taken on 9 MAR 84



	10:00	11:00	12:00	13:00	14:00	15:00	16:00
Monday	509	568	579	120	554	562	432
Tuesday	565	663	675	129	613	616	469
Wednesday	547	599	586	135	595	533	271
Thursday	541	556	542	110	541	423	315
Friday	502	540	497	116	526	420	241

Histogram for room survey ta[illegible] from room aggregation file SPR84 created [illegible]er database SPR 84 on 9 MAR 84

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COLLEGE OF FURTHER EDUCATION

Room : ALL ROOMS
Room Type : ALL TYPES
Site : ALL SITES

FEMIS Release 2a

Taken on 13 MAR 84

Figure 5

Number of rooms in this category : 70

Mean room size :	19.90
Mean class size :	9.12
Room hours used :	1775.00
Room hours available :	2450.00
Room frequency factor :	72.45 %
Seat hours used :	16190
Seat hours available :	48755
Seat occupancy factor :	45.83 %
Utilisation factor :	33.21 %

: Room
0 Class

Envelope for room survey taken from room aggregation file SPR84 created under database SPR 84 on 13 MAR 84

6. Space allocation systems

The problems referred to in section 4, of mismatch between group and room size, and of peaking, are often the result of the way that the timetabling and space allocation procedures are carried out within an institution: typically one academic from each department or faculty is asked to draw up a teaching timetable, based on academic requirements; these timetables are then handed to a central administrator (very often in a small college the assistant director, or in a school the deputy head) who has the thankless task of fitting the timetable into the existing available teaching space.

There are more or less complex computer programs which can help him to do this, including those which identify clashes when a wide range of optional subjects is offered and others which suggest how the number of spaces required at each teaching period can be kept to a minimum. See Beveridge and Hay (1979).

However, to the knowledge of the authors, there is only one system designed specifically to optimise space use while responding to all academic exigencies and which carries out the two processes, of timetabling and of space allocation, simultaneously. Further details of the system are available in DES (1977). Very briefly, the system operates as follows, using as a basic assumption that each teaching activity must unite a staff member, a student group, a time and a place, each item having initially equal status, but being liable to reordering by the user.

There are two fundamental sets of data, the first describing the nature and availability of staff, students and rooms, and the second describing the activities which have to be scheduled and accommodated.

For the first set the following information is provided for each student group (where a student group is the smallest group of students timetabled together regularly and which at the limit might consist of only one student), for each staff member and for each space used for teaching:

1. name;
2. availability (items are available, not available or preferably not available for each of 48 hours each week, i.e. 8 hours a day for 6 days);
3. size;
4. base location (zone and department); and
5. for rooms only, type (which is decided upon by the user, and which generally falls in a range between

completely unserviced and highly serviced).

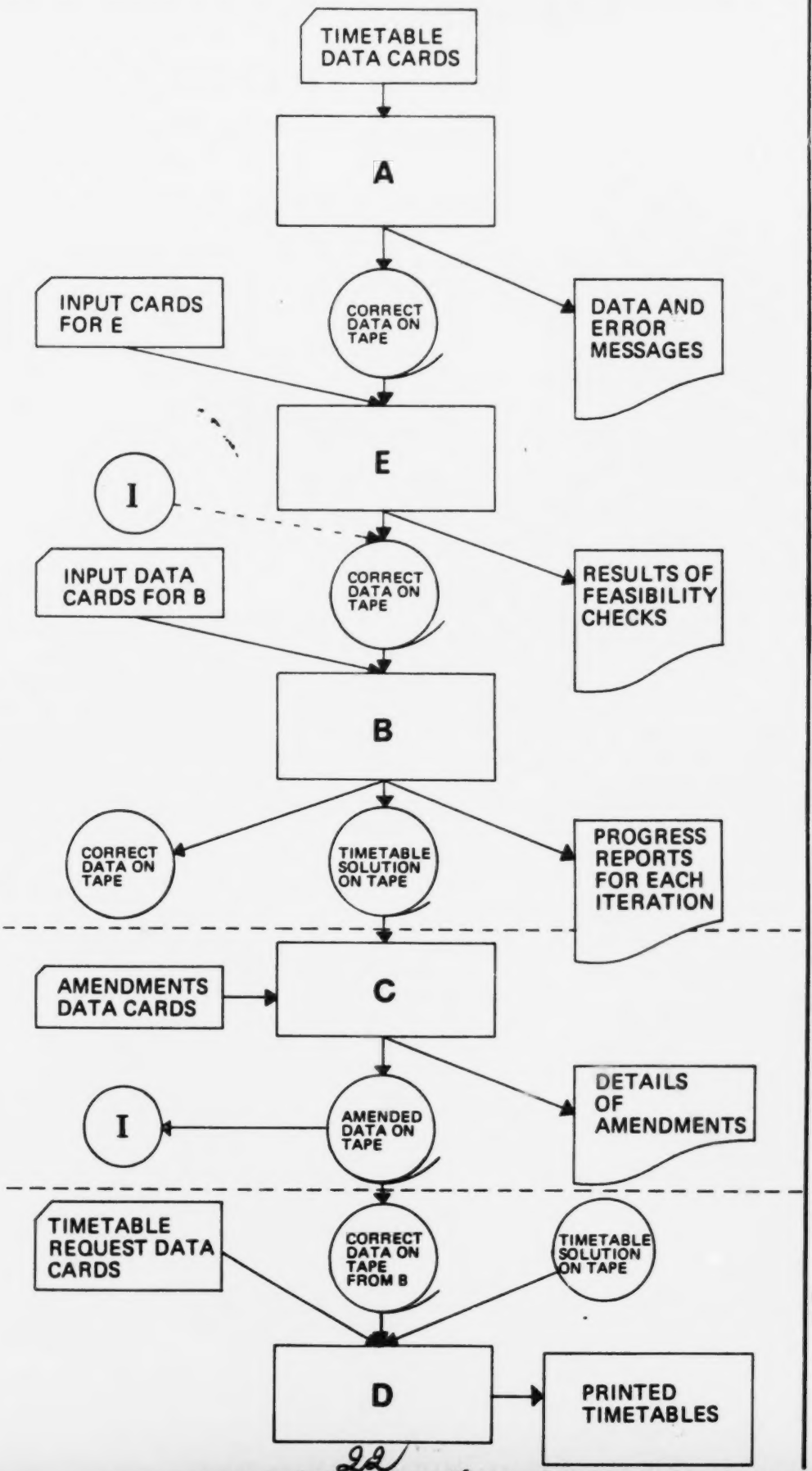
The second set of data comprises a list of all the activities which the user needs to timetable and accommodate. Each activity description includes:

1. a name;
2. a length (duration in hours);
3. the number of times the activity occurs each week;
4. name of staff involved;
5. name of student group involved;
6. a room choice option (either a specific room or one of a set of suitable rooms, or a preferred room type and location).

Once the data are entered and checked, the program orders the activities so as to deal with the most difficult first, thus ensuring that the best solution is reached in the shortest possible time. The order of days and period can be adjusted so as to reduce peaking. A search is made for a suitable space and time, with size, location and room type constraints being successively relaxed as necessary. It may not be possible in a real educational institution to achieve a solution of 100% using the computer program alone, but when at least 90% of all activities have been scheduled, it is usually possible to deal with the remainder manually. Even in the earliest applications of the system (and see Bowles 1979, and Chan 1978) and including many individual preferences and constraints, it was possible to achieve frequency levels of 75% and average occupancy levels of 80%. Higher than usual space utilisation levels are thus in practice compatible with the production of satisfactory timetables. Figure 6 shows the main data flows in the program suite.

Figure 6

SYSTEM FLOWCHART FOR TIMETABLING AND SPACE ALLOCATION SYSTEM



To summarise, the objectives of this suite of programs are:

1. to improve space use and provide an effective solution to an institution's timetabling problem by co-ordinating space use at the institutional level whilst maintaining the personal choices usually included at the departmental level:

2. to provide a wide range of statistics on space utilisation and movement patterns generated by the timetable, thus enabling any under- or over-provision of various kinds of space to be recognised and the necessary action taken;

3. to enable explicit assessments to be made of the impact of new policy decisions on patterns of space use;

4. to enable administrators and academics alike to understand the effects of personal or departmental preferences on space use and space provision;

5. to provide detailed information to assist in the planning of new accommodation and the adaptation of existing buildings. Space provision can be directly related to the projected pattern of activity requirements. See Rawlinson (1972) and Laboratories Investigation Unit (1977).

The users of the system include universities and polytechnics in the United Kingdom and abroad and the enhancements which they are able to make (including a current development to provide a short-order room booking facility) are made available to all other users.

7. Conclusion

The attached bibliography covers a wide range of work relating to educational space planning and use, but for a summary of the principles behind efficient building utilisation see particularly DES (1974).

Although the ideas and techniques outlined here were developed in response to pressures of increasing numbers of students, they have been found to be equally useful in the present climate (in the U.K. and Europe) of falling or static student numbers, and of severe financial cutbacks. Since it is being increasingly recognised that buildings are very expensive to run and maintain, institutions are trying both to shed unwanted buildings, or to make them pay; either way the use of the remaining buildings has to be as efficient as possible. Equally, if it decided to use accommodation left spare by falling numbers to provide for different uses (typically in the U.K. for better staff accommodation in Further Education colleges) the techniques are

invaluable in deciding how best to rearrange the overall areas of institutional buildings. Grace Kenny is currently engaged in a research study in the Architects and Building Group at DES which aims to look at the building implications of the current process of restructuring Advanced Further Education in the U.K. A Design Note giving general principles and examples of good practice will be published later in 1984. A forthcoming book (Davies, 1984) on university management will also include a chapter on the planning and management of space and facilities.

The techniques have been adopted in all sectors of education in the United Kingdom, and are being incorporated into a wide-ranging management information system being developed at the Further Education Staff College - Further Education Management Information System. Additionally the ideas are beginning to be disseminated in Europe and as far away as in the People's Republic of China. The Architects and Building Group is currently collaborating on a space planning exercise with the Chinese Academy of Sciences. It is hoped that this paper might lead to further collaborations with public and educational organisations in the United States.

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